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Assessment of Rectal Tumor Infiltration Utilizing Endorectal MR Imaging and Comparison With Endoscopic Rectal Sonography

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Background: The preoperative assessment of depth of invasion of rectal carcinoma is increasingly important as new treatment methodologies are developed. Accuracy of preoperative endorectal MR imaging was therefore compared with that of the endoscopic rectal sonography in determining depth of invasion of rectal carcinomas.
Method: From March 1993 to April 1994, 10 consecutive patients with biopsy-proven rectal carcinomas were imaged with both endorectal MR imaging and endoscopic rectal sonography. These two studies were performed an average of 2.7 days apart in each patient. All 10 patients had surgical resection of the rectal carcinoma within days of imaging studies. TNM staging of each malignant lesion was correlated with the imaging reports.
Result: Staging accuracy was 80% for endorectal MR imaging and 70% for endoscopic rectal sonography. With MR imaging, one T2 lesion was overstaged and one T3 lesion was understaged. With sonography, two T2 lesions were overstaged and one T3 lesion was understaged. One MR error resulted from misinterpretation. All other staging errors occurred in patients with tumor spread into, but not through, the muscularis propria or with microscopic spread through this layer.
Conclusions: Endorectal MR imaging and endoscopic rectal sonography have similar accuracy for assessing depth of invasion of rectal carcinoma.
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KEY WORDS: carcinoma; magnetic resonance imaging; neoplasm staging; rectal neoplasms, ultrasonography

INTRODUCTION

Rectal carcinoma is a frequently occurring malignant neoplasm in the United States; approximately 50,000 new cases of rectal carcinoma are diagnosed yearly [1]. The major factors determining the curability of rectal carcinoma are depth of tumor infiltration and lymphatic or hematogenous spread of malignancy [1]. In addition, surgical options for treating rectal carcinoma vary from transrectal local excision to anal sphincter-sparing surgery to extensive abdominoperineal resection. Adjuvant preoperative radiation therapy is useful in reducing recurrence in patients with deeply invasive carcinomas

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TABLE I. TNM Staging System for Rectal Carcinoma

Stage	Level of involvement
Tumor	
T1	Limited to mucosa and submucosa
T2	Extension into but not through muscularis propria
T3	Invasion of perirectal fat
T4	Invasion of adjacent structures
Nodes	
N0	No involved lymph nodes
N1	Fewer than four regional nodes positive for tumor
N2	More than four regional nodes positive for tumor
N3	Distant nodes positive for tumor
Metastasis	
M0	No metastasis
M1	Distant metastasis

[2–4]. The preoperative determination of optimal treatment depends on accurate preoperative staging. Both endorectal MR imaging and endorectal sonography have been reported to be more accurate in assessing depth of tumor infiltration in patients with rectal carcinoma than have physical examination or other imaging techniques, including CT and standard body-coil MR imaging [1,5–13]. Our study was designed to evaluate further the effectiveness of endorectal MR imaging in determining depth of tumor infiltration in patients with rectal carcinoma and to compare the results with those obtained with endorectal sonography, a technique with proven usefulness for this application [10–13].

MATERIALS AND METHODS

From March 1993 to April 1994, 10 consecutive patients with biopsy-proved rectal carcinomas were imaged with both endorectal MR imaging and endoscopic rectal sonography. The endorectal MR imaging and endoscopic rectal sonography studies were performed an average of 2.7 days apart. Five patients were imaged after downstaging regimes and then underwent surgical resection of the lesions. The other five patients underwent rectal tumor resection an average of 6.8 days after the imaging studies. No patients were excluded from the study during this period.

All 10 patients had surgical resection of the rectal carcinoma within days of the imaging studies. Eight patients had sphincter-sparing procedures (five low anterior resections, three transrectal excisions), and two patients underwent abdominoperineal resection with colostomy formation. TNM staging (Table I) of each malignant lesion was correlated with the imaging reports.

Endorectal sonography was performed with an endoscopic sonographic system. This system allows limited direct visualization of the gastrointestinal tract as well as of the region being examined. The use of a rotating real-time mechanical transducer attached to the endoscope provides a 360° radial sector scan directed at a right angle to the endoscope. A 7.5-MHZ transducer was used for this study. Each patient was given a cleansing enema and placed in the left lateral position. The transducer was then inserted into the rectum. Sedation was not necessary. Sonography was performed by one of the radiologists on our faculty. Optimal sonographic transmission was provided by infusing deaerated water into a latex balloon surrounding the transducer, or by injecting water into the rectum (or both), thus producing an acoustic window for sonography.

A 1.5-T MR imaging unit was used for MR imaging. Patients were not sedated and were imaged with a standard endorectal prostate coil (coil dimensions: length = 10 cm, diameter = 4 cm) placed after digital rectal examination to exclude rectal stenosis, which might have precluded use of the endorectal coil. The concave side of the endorectal coil was directed toward the palpated lesion to facilitate maximal signal-to-noise parameters. The balloon surrounding the endorectal surface coil was inflated with ~50 ml of air. The patient was in supine position and 1 mg of glucagon was injected intramuscularly immediately prior to MR imaging.

A sagittal T1-weighted (500/11[TR/TE], 128 × 128 matrix; 48 cm field of view) image was initially obtained to ascertain the position of the endorectal coil. Spin-echo T1-weighted axial (600/12, 128 × 128 matrix, 12 cm field of view) and T2-weighted fast spin-echo sequences (4,000/144, 256 × 256 matrix, 10–12 cm field of view) were performed. These images were obtained with 3-mm-thick slices with a 1 mm gap for the T1-weighted images and interleaved spacing for the T2-weighted sequence. Fast spin-echo T2-weighted sagittal (4,000/144, 256 × 256 matrix, 12 cm field of view) and T2-weighted oblique coronal (4,000/132, 256 × 256 matrix, 12 cm field of view) images were obtained with a 1 mm gap. Additional axial T1-weighted spin-echo images (600/12, 128 × 128 matrix) were obtained with the body coil with 5-mm-thick slices and a 1-mm gap from the midprostate through the kidneys.

The muscularis propria layer appears as a well-demarcated, low signal, and hypoechoic circumferential band on endorectal MR imaging and endorectal sonography, respectively. Obliteration of this band by adjacent tumor was the criterion for diagnosing tumor as stage T3 or greater. Criteria for this and other tumor staging decisions with endorectal MR imaging and endoscopic rectal sonography were based on previously described data [8,9,11,12].

Interpretation assignments were determined by our routine clinical rotation. The sonographic images were interpreted prospectively by one of two radiologists experienced in sonography. Similarly, the MR imaging studies were read prospectively by one of four radiologists with experience in MR imaging. Readers were blinded to the other imaging technique studied. Fischer's

TABLE II. Endorectal MR Imaging Tumor Stage Vs. Histopathologic Stage

	Endorectal MR imaging	Histopathology T2	Histopathology T3
	T2	4	1
	T3	1	4
Total		5	5

TABLE III. Endoscopic Rectal Sonography Tumor Stage Vs. Histopathologic Stage

	Endoscopic rectal sonography	Histopathology T2	Histopathology T3
	T2	3	1
	T3	2	4
Total		5	5

exact test was used statistically to compare the staging results of endorectal MR imaging and endoscopic rectal sonography.

RESULTS

Both endorectal MR and endoscopic rectal sonography were well tolerated by all patients with both exams causing mild discomfort. Tables II and III compare the imaging assessment of tumor depth of invasion for both endorectal MR imaging and endoscopic rectal sonography with the histopathologic findings.

The accuracy for staging depth of tumor invasion was 80% for endorectal MR imaging and 70% for endoscopic rectal sonography. This difference was not statistically significant with Fischer's exact test. One stage T2 lesion was overstaged as T3, and one stage T3 lesion was understaged as T2 based on endorectal MR imaging findings. With endoscopic rectal sonography, two stage T2 lesions were overstaged as T3, and one stage T3 lesion was understaged as T2.

The staging errors were analyzed retrospectively. One T3 lesion was understaged as T2 based on a misinterpretation of the endorectal MR imaging findings. The one T3 lesion understaged by endoscopic rectal sonography findings was found to have only minimal microscopic tumor invasion through the muscularis propria (Fig. 1). In all lesions overstaged by imaging findings (one by both endorectal MR imaging and endoscopic rectal sonography, and one by endoscopic rectal sonography only) specimens demonstrated invasion into, but not through, the muscularis propria.

In six patients, three with stage T2 tumors and three with stage T3 tumors, depth of invasion was assessed accurately with both imaging techniques (Figs. 2 and 3). Of the staging errors, one stage T2 lesion was overstaged as T3 by both endorectal MR imaging and endoscopic rectal sonography findings. For the three remaining lesions staged incorrectly by one imaging technique, two were proved T3 lesions and one was a T2 lesion. In these three lesions, depth of invasion was accurately assessed by means of one of the imaging techniques but incorrectly staged with the other technique.

Of the seven patients who had surgical lymphadenectomy, four were found to harbor node metastases.

DISCUSSION

Rectal carcinoma is a frequently occurring neoplasm, and the best opportunity to cure patients with this disease is complete surgical resection of the tumor. Standard surgical management has been abdominoperineal resection with formation of a permanent colostomy. Newer surgical techniques include low anterior resection with anal sphincter sparing and transrectal local excision of tumors. At our institution, patients with preoperatively staged T1 and T2 rectal carcinomas that are not poorly differentiated and are located within reach of the anus are candidates for transrectal (sphincter-sparing) surgical excision. All of these patients receive adjuvant radiation therapy and chemotherapy, as no lymphadenectomy is performed. Rectal carcinomas located higher in the rectum that are staged T1 or T2 can be treated with anal sphincter-sparing low anterior resection with lymphadenectomy. Adjuvant postoperative radiation and chemotherapy are used in these patients if any lymph node metastases are found at surgery. Lesions staged T3 or higher and T1 and T2 lesions that are poorly differentiated histologically are treated with abdominoperineal resection with permanent colostomy and adjuvant radiation therapy and chemotherapy. Some T3 lesions treated preoperatively with radiation therapy and chemotherapy can be downstaged and then treated with sphincter-sparing surgery rather than abdominoperineal resection. Obviously, anal sphincter-sparing techniques are desirable when cure rates comparable to standard abdominoperineal resection are achievable. Accurate preoperative assessment of depth of tumor infiltration is a major factor in preoperative treatment planning. Thus far, the most promising techniques for preoperative assessment of tumor infiltration have been endorectal MR imaging and endorectal sonography [5–13].

Our results suggest that both techniques have limitations for accurately assessing depth of invasion, especially where minimal, microscopic invasion is present. However, our results do agree with previous studies suggesting improved accuracy rates for each technique compared with staging by physical examination, CT, or body-coil MR imaging [1,5–7]. Our results suggest that both endorectal MR imaging and endoscopic rectal sonography have similar accuracy for assessing depth of invasion of rectal carcinoma.

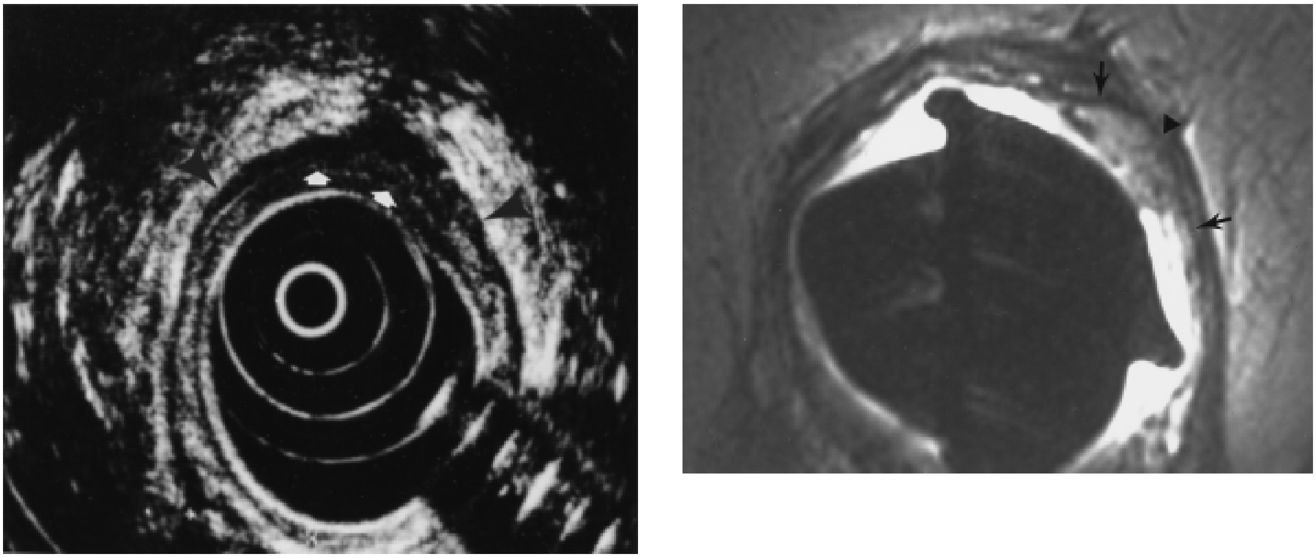

Fig. 1. Endoscopic rectal sonogram and endorectal MR image from a patient understaged with endorectal sonography. **A.** Axial endorectal sonogram of the rectum demonstrates a hypoechoic tumor (arrows), which is apparently contained within the muscularis propria layer (arrowheads) and was interpreted as a stage T2 lesion. **B.** Axial T2-weighted MR image in the same patient reveals a well-circumscribed carcinoma. The muscularis propria layer is well demarcated (arrows) but is obliterated where it abuts the thickest area of the tumor (arrowhead), indicating a stage T3 carcinoma. Upon resection, this lesion was found to extend through the muscularis layer (stage T3).

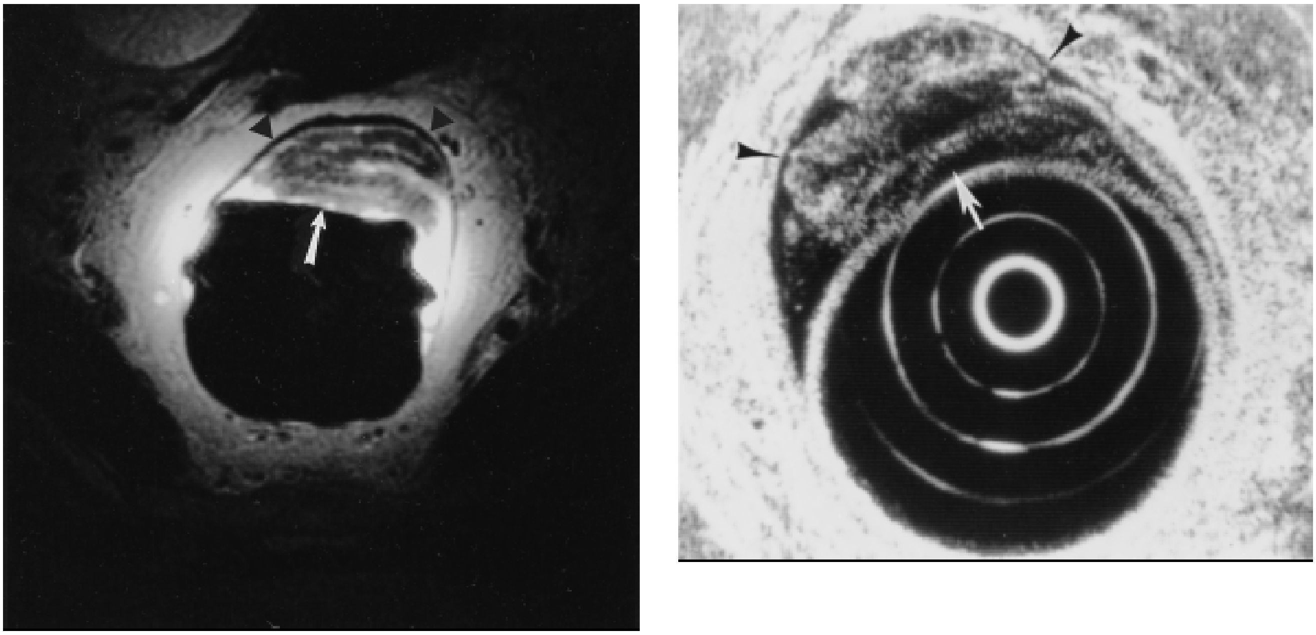

Fig. 2. Endorectal MR image and endoscopic rectal sonogram of a stage T2 adenocarcinoma. **A.** Axial T2-weighted endorectal MR image demonstrates a well-defined mass (arrow) within an intact muscularis propria layer (arrowheads). **B.** Axial endorectal sonogram of the same patient also demonstrates the mass (arrow), which is superficial (stage T2) to the muscularis propria layer (arrowheads).

Each technique has its own strengths and limitations. Both tests may be impossible to perform in patients with severely stenotic infiltrating lesions that limit the passage of diagnostic instruments through the rectal lumen. We did not encounter this problem in any of the patients in this series. Endorectal MR imaging cannot be performed in patients with pacemakers, in some patients with implanted surgical devices, and in patients who are severely claustrophobic. Endorectal MR imaging is also limited in visualizing tumors that are high in the rectum and those that span the rectosigmoid junction. The endorectal surface coil we currently use is a rigid device with a small radial area of acceptable signal-to-noise ratio imaging. In one patient, the tumor was incompletely visualized because it extended above the upper extent of the endorectal surface coil. However, in this case tumor staging was

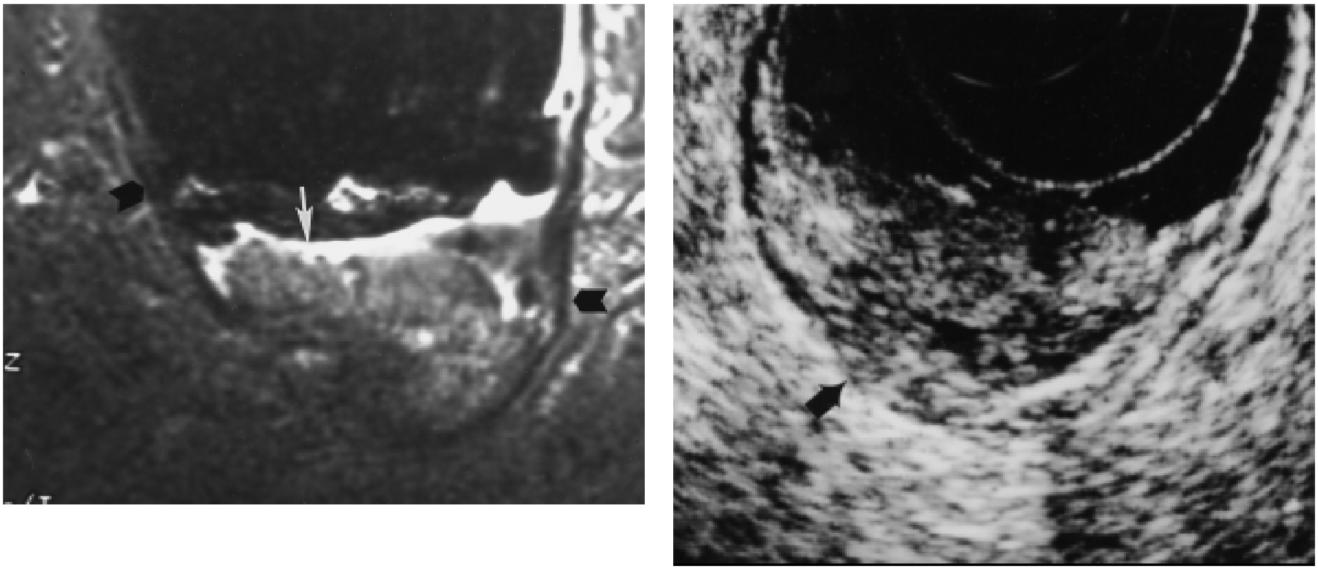

Fig. 3. Endorectal MR image and endoscopic rectal sonogram of a stage T3 adenocarcinoma. **A.** Axial T2-weighted endorectal MR image demonstrates a posteriorly located invasive rectal carcinoma (arrow). This inhomogeneous lesion extends through the muscularis propria (stage T3). This muscular layer is well defined around the remainder of the rectum (arrowheads) but is obliterated adjacent to the tumor. **B.** Axial endorectal sonogram of the same patient correlates with the endorectal MR image, demonstrating focal spread (arrow) through the muscularis propria layer.

accurate because the portion of the tumor that extended through the muscularis propria layer was seen in the segment of tumor that was visualized with the endorectal coil.

We have found that our referring surgeons prefer the endorectal MR images over the endoscopic rectal sonography images for surgical planning because of the anatomic detail, images that are similar to surgical anatomy, and orientation seen with multiplanar endorectal MR imaging. The relationship of the tumor to perirectal structures, genitourinary organs, and the pelvic sidewalls and its exact location within the rectal wall are readily demonstrated with endorectal MR imaging. In addition, we routinely use standard body-coil images of the entire pelvis and lower abdomen in patients undergoing endorectal MR imaging. This allows us to search for pelvic and lower abdominal metastases. The examination could be expanded to examine the entire abdomen. The accuracy of body-coil MR imaging for the detection of lymphadenopathy is similar to that seen with CT scanning [14–16], the accepted standard imaging technique for this task.

Endoscopic rectal sonography has the advantage of flexibility and the coupling of sonography with endoscopy. Newer endoscopically guided ultrasound probes can be used for lesions in the rectum as well as for lesions more proximal in the colon, well beyond the range of endorectal MR imaging. Endoscopically guided endorectal sonography often requires a coordinated effort between gastroenterologists and radiologists, which may be a logistical disadvantage when compared with endorectal MR imaging, which is performed solely by radiologists. A disadvantage of endoscopic rectal sonography is the inability to evaluate the patient with endorectal sonography for evidence of metastases beyond the immediate perirectal region. Endoscopic rectal sonography can demonstrate perirectal lymph nodes with accuracy similar to that of endorectal MR imaging, but unlike endorectal MR imaging, the same imaging equipment cannot be used for staging of tumor beyond the perirectal region.

Cost is also a consideration when selecting an examination technique. The charge for endorectal MR coupled with MR of the pelvis and lower abdomen is $1,000 per patient. The charge for endoscopic rectal sonography is $365 per patient, a substantially lower cost.

Assessment of tumor spread to lymph nodes is a separate but important aspect in staging rectal carcinomas. One common limitation of both endorectal sonography and endorectal MR imaging is the relative inaccuracy of both in detecting tumor spread to perirectal lymph nodes. When present, regional lymph node spread correlates with poor long-term prognosis [1]. Unfortunately, lymph node size and number have been unreliable indicators of tumor involvement for perirectal lymph nodes in previous studies [1,6,7,9,10]. However, depth of invasion remains a key element for surgical and preoperative treatment planning, and this was the focus of this study. In our institution, all patients with rectal carcinoma either undergo lymphadenectomy, or they receive prophylactic radiation and chemotherapy aimed at treating potential metastatic disease. Therefore, preoperative detection of local lymph node metastases does not affect rectal tumor resection decisions.

In summary, when staging rectal carcinomas accurate determination of depth of invasion is important for treatment planning. The current series of patients had both endorectal MR imaging and endoscopic rectal sonography to assess the accuracy of these imaging techniques in determining depth of invasion of rectal carcinomas. Endorectal MR imaging appears to be a promising technique that may improve the accuracy of preoperative determination of tumor depth of invasion. From this series we conclude that endorectal MR imaging is at least as accurate as endoscopic rectal sonography in determining depth of tumor infiltration in patients with rectal carcinoma. This study is somewhat limited by the small number of patients in the series and by the limited experimental design of a retrospective study. Nevertheless, endorectal MR imaging is an emerging technique for rectal carcinoma staging, and this study shows it has potential for this application. In our institution, endorectal MR imaging has been more readily accepted by referring surgeons than has endoscopic rectal sonography for staging rectal carcinoma. The ability to couple standard staging MR imaging of the abdomen and pelvis with endorectal MR imaging examinations is an additional potential advantage of endorectal MR imaging.

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